1 390 782

PATENT SPECIFICATION

(11) 1 390 782

(21) Application No. 51818/74 (22) Filed 2 March 1972 (19)

(62) Divided out of No. 1 390 781

(44) Complete Specification published 16 April 1975

(51) INT. CL.² F28F 1/10

(52) Index at acceptance

F4S 1 2A3 2A5 2B11 2B1 2B3 2B4 2B6 4E2B 4F1

(72) Inventor FRED WELLINGTON FRENCH

(54) IMPROVEMENTS IN AND RELATING TO HEAT-EXCHANGE TUBING

(71) We, NORANDA METAL INDUSTRIES INC., a corporation organised and existing under the laws of the State of Delaware, United States of America, of 1530 Curtis Road, Bellingham in the County of Whatcon and State of Washington, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to heat-exchange tubing and, more particularly to finned heat-exchange tubing.

The type of heat-exchange tubing with which the present invention, is concerned is provided with inwardly extending fins, or so-called "inner" fins, on its peripheral wall. Tubing of this type is well known for its heat-exchange properties which vary from good to excellent, depending on the inner-fin pattern and size, the particular heat-exchange application, and other factors. However, even this type of tubing does not lend itself to certain exacting heat-exchange requirements for various applications. There are several reasons for this, and chief among them is that heat-exchange of the fins and also the peripheral wall of such tubing with fluid passing through the latter is inadequate for certain purposes regardless of the height and number of the fins.

The present invention seeks to provide heat-exchange tubing of this type which meets many exacting heat-exchange requirements that cannot be met by the aforementioned known inner-fin tubing.

According to the present invention there is provided a longitudinal heat-exchange tubing comprising a peripheral metal wall having two opposite spaced wall sections and two opposite side wall sections joining said opposite spaced wall sections; and spaced metal fins projecting inwardly of the tubing from said wall sections and extending longitudinally of the tubing; and wherein the fins on either of said opposite spaced wall sections are inclined to the longitudinal axis of the tubing so that the fins on one of said opposite spaced wall sections are inclined to and cross the fins on the other of said opposite spaced wall sections, and the fins on either of said opposite spaced wall sections extend with their tips beyond the level of the tips of the fins on the other opposite wall section but are spaced from said other opposite wall section.

Preferably the two opposite spaced wall sections are flat and parallel and said fins are integral with said walls.

Preferably the two opposite spaced wall sections form the predominant part of said peripheral wall.

In one form of the invention the thickness of said peripheral wall is less than the fin height.

With this arrangement, the path of fluid through the tubing is even more tortuous past the fins therein where the fins on the opposite flat wall sections cross each other, involving additional diversion of fluid within the channel between successive fins over the tips of opposite fins projecting within the confines of the channels. Further, where the fins on the opposite flat wall sections are inclined to and cross each other, the fins will, over the extent of their interpress at their crossings, readily give way in denting and interlocking without distoring the fin pattern.

The invention will now be described further, by way of example, with reference to the accompanying drawings in which:—

Fig. 1 is a plan view of heat-exchange tubing according to the present invention:

Fig. 2 is a cross-section through the heat-exchange tubing of Fig. 1 along the line 2—2;

Fig. 3 is a section through the tubing substantially along the line 3—3 in Fig. 2;

Fig. 4 is an enlarged section through part of the tubing substantially along the line 4—4 of Fig. 3;

Fig. 5 is a side view, partly in section, of a heat exchanger embodying heat-exchange tubing according to the present invention;

Fig. 6 is a side view, partly in section, of a modified heat-exchanger embodying heat-

[Price ...]

exchange tubing in accordance with the present invention;

Fig. 7 is a view of heat-exchange tubing according to the present invention with a longitudinal twist;

Fig. 8 is a section through heat-exchange tubing according to th present invention which is also cross-sectionally curved;

Fig. 9 is a perspective view of heat-exchange tubing according to the present invention which is also bent longitudinally into successive helical turns; and

Fig. 10 is a cross-section through a further embodiment of heat-exchange tubing in accordance with the present invention.

Referring to the drawings, and more particularly to Figs. 1 to 4 thereof, the reference numeral 10 designates heat-exchange tubing having a peripheral metal wall 12 of oblong cross-section and a multitude of metal fins 14 with tips 16. The peripheral wall 12 provides two flat opposite, and preferably parallel, wall sections 18, and opposite side wall sections 20 which join the flat wall sections 18, with the flat wall sections 18 constituting in this instance a far predominant part of the wall 12. The fins 14, which project inwardly from the wall 12 and are preferably formed integrally therewith, are of the same height. Successive fins 14 on the wall 12 are preferably equally spaced, and the fins on either flat wall section 18 extend parallel to each other and at an inclination to the longitudinal axis x of the tubing, with the fins on the respective wall sections 18 being also inclined to and crossing each other (Fig. 3).

The fins 14 on either flat wall section 18 extend with their tips 16 beyond the level of the tips of the fins on the opposite flat wall section but remain spaced from the latter. The fins 14 on the opposite flat wall sections 18 are, at and over the extent of their crossings 40, interpressed and thereby interlocked due to mutual denting of the fins thereat as at 42 (Fig. 4). Thus, due to the mutual denting of the fins at their crossings in consequence of partially flattening the round blank to the extent of part-way interprojecting the fins on the opposite flat wall sections, the fin pattern as such remains intact and is not distorted (Fig. 3). Owing to the part-way interprojection of the fins in this tubing, the fluid path therethrough is quite tortuous and may even vary considerably with different degrees of interprojection of the fins. Different interprojection of the fins is thus a tool toward achieving good heat-exchange and meeting other widely varying requirements, such as volumetric flow rate of a fluid passing through the tubing or to keep pressure drop of the passing fluid within prescribed limits. The fin height may vary widely from less than the thickness of the peripheral blank wall to many times such wall thicknesses. Thus, the number of fins, their height within the above wide range, and the peripheral extent of the wall of flat tubing may vary widely to meet many different, including heat exchange, requirements. Insofar as the height of the fins is concerned, the same is for many, but not all, applications greater than the thickness of the peripheral wall of the tubing.

The "flat" metal tubing 10 is advantageously formed from a round inner-fin tube blank not shown in the drawings by a method which involves partially flattening the blank to form opposite peripheral wall portions thereof into the flat parallel wall sections 18.

In the described flat heat-exchange tubing 10 the two opposite flat wall sections constitute the predominant part of the peripheral wall of the tubing. While this is preferred for exacting heat-exchange and also other requirements of many applications, such as cooling the transmission oil of automotive vehicles, just to mention one such application, the advantages of having the fins within full reach of the interior of flat tubing are secured even where the two flat opposite wall sections do not constitute a predominant part, or even constitute less than one-half, of the peripheral wall of the tubing.

Reference is now had to Fig. 5 which shows a heat-exchange unit 50 using a length or piece 52 of the flat inner-fin tubing 10. The opposite ends 54 and 56 of the tube piece 52 are in communication with the interior of casings 58 and 60, with the tube ends 54 and 56 being fitted in, and conveniently brazed to, slots 62 in the respective casings 58 and 60. The casings 58 and 60 have tapped holes 64 and 66 for connection with conduits through which to lead a fluid, liquid or gas, to and from the unit 50 for temperature modification, such as cooling, for instance.

While in the described heat-exchange unit 50 the end casings 58 and 60 and their slots 62 are rectangular in section Fig. 6 shows a heat-exchange unit 70 of which the end casings 72 and 74 are circular in section. To this end, the length or piece 76 of inner-fin tubing is, in its formation from a round inner-fin tube blank, partially flattened only over its longitudinal extent *l* so that opposite end lengths 78 and 80 of the tubing remain cylindrical, and these cylindrical end lengths 78 and 80 are connected with the casings 72 and 74.

In many heat-exchange applications, the fluid passing through the flat inner-fin tubing is under operating pressure which may be sufficiently high to "open" the tubing by forcing the opposite flat sections 18 of the peripheral wall more or less apart, and thereby greatly reduce the heat-exchange capacity of the tubing, if not render the tubing unfit for further use in a particular heat-exchange application. Opening of the tubing in this fashion and from this cause is in many cases prevented by additionally curving or twisting

the tubing longitudinally, transversely, or both longitudinally and transversely, and thereby reinforcing the tubing against such opening. Thus, a length 90 of the flat inner-fin tubing may be twisted about its longitudinal axis x (Fig. 7) whereby the tubing becomes curved, longitudinally as well as transversely, over its lengthwise extent, and is thereby reinforced against opening under internal pressure. The tube length 90 may be twisted by forcing the same through a correspondingly twisting opening in a die 92.

Fig. 8 shows a piece 94 of the flat inner-fin tubing which is transversely curved for reinforcement against opening under internal pressure. The initially flat tube piece 94 may to this end be drawn through a die 96 with an opening of the outline of the curved tubing.

Fig. 9 shows a piece 98 of the featured flat inner-fin tubing which is longitudinally curved for reinforcement against opening under internal pressure. This is achieved in this instance by bending the flat tubing around a cylindrical arbor 100. The exemplary tube piece 98 is of quite extensive length with correspondingly large heat-exchange capacity, and in order greatly to reduce the lengthwise expanse of the longitudinally curved tubing, the tubing is bent around the arbor 100 in successive and more or less closely adjacent helical turns 102.

While the flat heat-exchange tubing described so far has only inner-fins, such flat tubing may have both, inner and outer fins. Thus, Fig. 10 shows flat heat-exchange tubing 104 which has inner and outer fins 106 and 108. The outer fins 108 extend in this instance parallel to the axis of the blank, but they may also extend helically.

In a further embodiment (not shown in the drawings) of the tubing 10 there is interposed between the tips of the fins on the opposite flat wall sections a longitudinal strip of any suitable brazing material. One of these strip materials, which is commercially available, is sold under the trade mark SIL-FOS and manufactured by Handy and Harman. The brazing strip is inserted in the course of flattening an initially round inner-fin tube blank into the flat tubing, with the strip being engaged by the tips of the fins. The flat tubing is then heated, as in a furnace for example, to melt the brazing strip and brace the fins together at their crossing tips, with the excess brazing material spreading over nearby portions of the fins. The tubing, being thus brazed together at the crossing tips of the fins, will not open under operational, including particularly high, internal fluid pressures. Brazing of flat tubing at the crossing tips of the fins is indicated where higher internal operational fluid pressures are involved, and especially for applications of such tubing which require that the same remains flat and is not to be curved for reinforcement against opening under internal fluid pressure.

Reference is hereby drawn to our copending application No. 9683/72 Serial No. 1,390,781) (Noranda Metal Industries Inc) in which there is disclosed and claimed a method of forming longitudinal heat-exchange tubing, which comprises providing a round metal tube blank having a longitudinal axis, a peripheral wall about said axis, and longitudinal inner fins on said wall, said fins being of equal height and spaced from said axis; and partially flattening the blank from two opposite sides into a substantially oblong cross-section with two opposite, parallel wall sections spaced apart such that the fins on one opposite wall section extend with their tips at least to the level of the tips of the fins on the other opposite wall section.

WHAT WE CLAIM IS:—

1. A longitudinal heat-exchange tubing comprising a peripheral metal wall having two opposite spaced wall sections and two opposite side wall sections joining said opposite spaced wall sections; and spaced metal fins projecting inwardly of the tubing from said wall sections and extending longitudinally of the tubing; and wherein the fins on either of said opposite spaced wall sections are inclined to the longitudinal axis of the tubing so that the fins on one of said opposite spaced wall sections are inclined to and cross the fins on the other of said opposite spaced wall sections, and the fins on either of said opposite spaced wall sections extend with their tips beyond the level of the tips of the fins on the other opposite wall section but as spaced from said other opposite wall section.

2. A longitudinal heat-exchange tubing as claimed in claim 1 wherein the tips of the fins on said opposite spaced wall sections are indented and interlocked at their crossings.

3. A longitudinal heat-exchange tubing as claimed in claim 1 or 2 wherein said fins are integral with said walls.

4. A longitudinal heat-exchange tubing as claimed in claim 1, 2 or 3 wherein said opposite spaced wall sections form the predominant portion of said peripheral wall.

5. A longitudinal heat-exchange tubing as claimed in claim 1, 2, 3 or 4 wherein the thickness of said peripheral wall is less than the projected height of the fins.

6. A longitudinal heat-exchange tubing as claimed in any of claims 1 to 5 wherein the fins on the respective opposite spaced wall sections are brazed together at their crossings.

7. A longitudinal heat-exchange tubing as claimed in any of claims 1 to 6 wherein said peripheral wall has fins projecting therefrom outwardly of the tubing.

8. A longitudinal heat-exchange tubing as claimed in any of claims 1 to 7 wherein the

tubing is curved in the direction of its longitudinal axis.

9. A longitudinal heat-exchange tubing as claimed in any of claims 1 to 8 wherein the tubing is twisted about its longitudinal axis.

10. A longitudinal heat-exchange tubing as claimed in claim 9 wherein the tubing is helically wound about a longitudinal axis with the two opposite spaced wall sections parallel to said axis.

11. A longitudinal heat-exchange tubing as claimed in any of claims 1 to 8 wherein the tubing has an arcuate cross-section.

12. A longitudinal heat-exchange tubing as claimed in any of claims 1 to 7 wherein the two opposite spaced wall sections are substantially flat.

13. A longitudinal heat-exchange tubing as claimed in any of claims 1 to 9, 11 and 12 wherein the two opposite spaced wall sections are substantially parallel.

14. A longitudinal heat-exchange tubing substantially as hereinbefore particularly described with reference to and as illustrated in Figs. 1 to 4 of the accompanying drawings.

15. A longitudinal heat-exchange tubing substantially as hereinbefore particularly described with reference to and as illustrated in Figs. 1 to 4 when modified in accordance with Figs. 7, 8 or 9 of the accompanying drawings.

16. A longitudinal heat-exchange tubing substantially as hereinbefore particularly described with reference to and as illustrated in Fig. 10 of the accompanying drawings.

W. P. THOMPSON & CO.,
Coopers Buildings,
12 Church Street,
Liverpool L1 3AB.
Chartered Patent Agents.

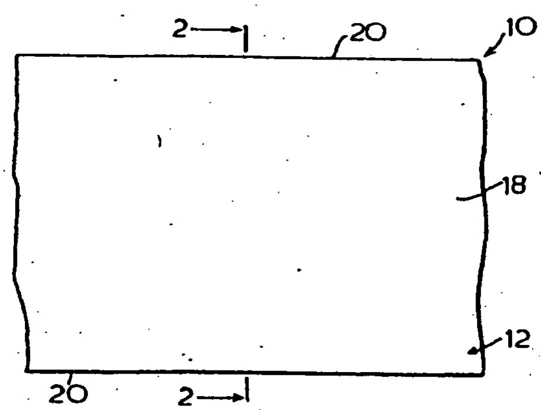
Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1975.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY
from which copies may be obtained.

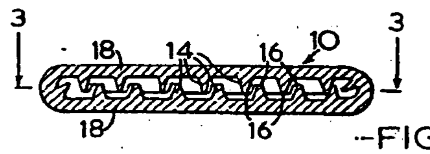
1390782 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

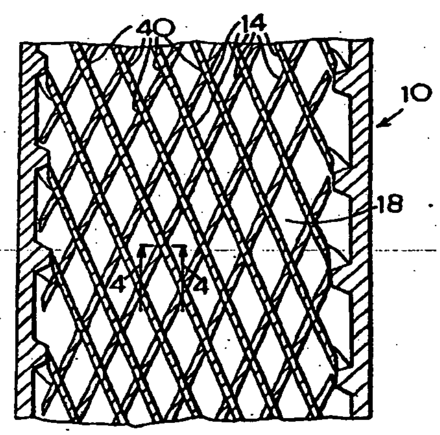
Sheet 1

--FIG.1--





--FIG.2--



--FIG.3--

1390782 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

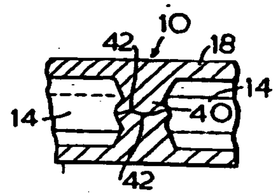


FIG.4.

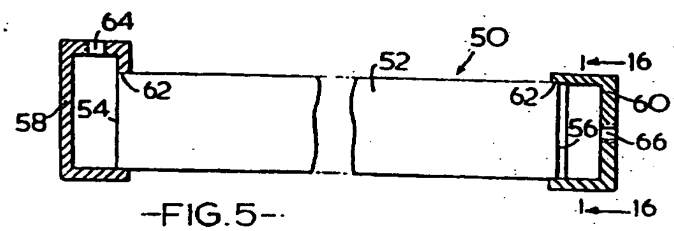


FIG.5.

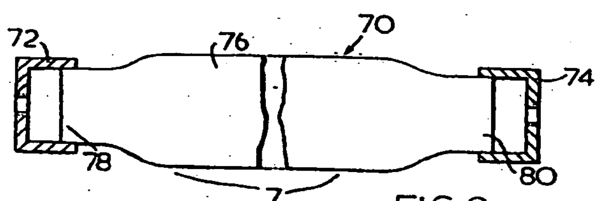


FIG.6.

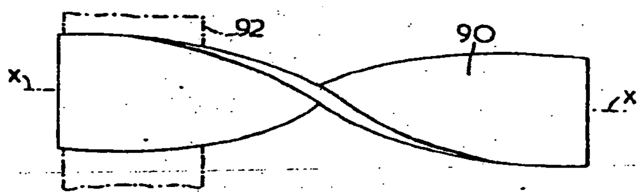


FIG.7.

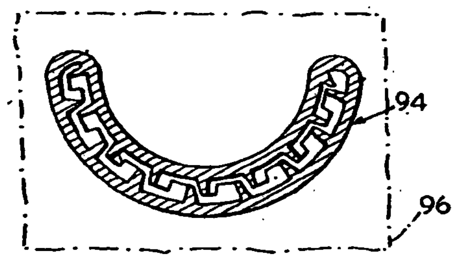
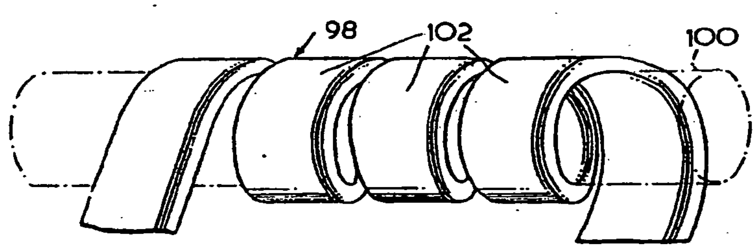
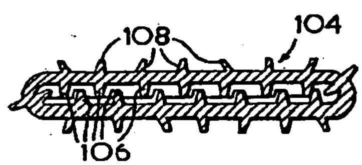


FIG 8



--FIG.9.--



--FIG.10.--